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**Full title:** Modelling Exposure to Multiple Childhood Social Risk Factors and Physical Capability and Common Affective Symptoms in Later Life

**Short title:** Modelling Exposure to Multiple Childhood Social Risk Factors and Health in Later Life

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## **Abstract**

**Objective:** This study presents three approaches i.e. cumulative risk, factor analysis and latent class analysis) to summarise exposure to multiple childhood social risk factors and to compare their utility when examining associations with physical capability and common affective symptoms in adults aged 60-64 years.

**Methods:** Data came from the UK MRC National Survey of Health and Development, with prospective childhood social risk factor data collected in 1950-1957 and retrospectively in 1989. Physical capability and common affective symptom data were collected in 2006-2011.

**Results:** The cumulative risk approach and factor analysis provided evidence that children who were exposed to multiple social risk factors had lower levels of physical capability and more symptoms of common affective symptoms in later life.

**Discussion:** The cumulative social risk approach and the use of factor analysis to identify contexts of social risk, may offer viable methods for linking multiple childhood social risk exposure to ageing outcomes.

**Key words:** life course; childhood social risk factors; physical capability; common affective symptoms

## Introduction

Understanding healthy ageing is important for informing strategies for reducing societal and individual costs of an ageing population, and requires a life-course approach.(Beard et al., 2016) Recently evidence has demonstrated that experience of early life social risk factors may compromise health in later life. (Kuh, Cooper, Hardy, Richards, & Ben-Shlomo, 2014; Kuh & Shlomo, 2004) Childhood social risk factors are also known to often co-occur. (Adler, Bush, & Pantell, 2012; Anda, Butchart, Felitti, & Brown, 2010; Bellis, Hughes, Leckenby, Perkins, & Lowey, 2014; Felitti et al., 1998) For example, children living in low-income families may tend to also live in poor housing which is overcrowded. (Evans, 2003) Accounting for co-occurrence rather than focusing on the impact of single childhood social risk factors is important, considering that it is probable that different combinations of childhood social risk factors may account for varying age-related physical and mental functioning decades later, (Caleyachetty et al., 2016; Evans, Li, & Whipple, 2013; Green et al., 2010; McLaughlin et al., 2010) the challenge is how to summarise multiple social risk factor exposure during childhood.

Traditionally, the number of dichotomous childhood social risk factors were summed into a score.(Evans et al., 2013) For non-binary exposures, a decision must be made about how to dichotomize the variable, either using a statistical cutoff (e.g. greater than one standard deviation above the mean, upper quarter) or on the basis of a conceptual categorization (e.g. manual vs. non-manual occupation, exposure vs no exposure to abuse). Dichotomous exposures are then summed. (Evans et al., 2013; J. Krieger & Higgins, 2002; Repetti, Taylor, & Seeman, 2002; Rutter, 1979) The cumulative social risk score does not take account of the

frequency, duration or intensity of exposure. The impact of cumulative social risk on children's health was first demonstrated in the Isle of Wight study, (Rutter, 1979) in which Rutter et al. assessed six childhood social risk factors: low parental socioeconomic status, large family size, severe marital discord, parental criminality, maternal mental illness, and foster placement, and found that after a certain number of childhood social risk factors are experienced, a dramatic increase in problem behavior outcomes occurs. The Adverse Childhood Experiences Study in the United States initially established that the number of childhood social risk factors were associated with poor health behaviours and outcomes in adulthood. (Chapman et al., 2004; Dong et al., 2004; Felitti et al., 1998) However, a conceptual drawback of summing the total number of childhood social risk factors is its insensitivity to the potential importance of particular social risk factors that may co-occur (i.e. domains of childhood social risk), (Appleyard, Egeland, van Dulmen, & Sroufe, 2005; Copeland, Shanahan, Costello, & Angold, 2009; Evans et al., 2013) missing the opportunity to empirically classify childhood social risk factors to unique groupings that might be etiologically distinct.

Domains of childhood social risk may be identified by three approaches. First, on a conceptual basis (for e.g. distinguishing between socioeconomic and psychosocial risk domains of exposure). Second, using a data-driven approach such as exploratory factor analysis (EFA). This is a variable-centered analysis, grouping childhood social risk factors according to the degree to which they are correlated to each other. The different impact of childhood psychosocial risk factors on mood and anxiety disorders has been demonstrated in the United States National Comorbidity Survey Replication (NCS-R). (Green et al., 2010;

McLaughlin et al., 2010) Exploratory factor analysis grouped 12 childhood adversities into 2 categories: those reflecting “maladaptive family functioning” (sexual abuse, physical abuse, neglect, parental mental illness, parental substance abuse, criminal behavior, and domestic violence) and “other childhood adversities” (parental death, parental divorce, other parental loss, childhood physical illness, and family economic adversity). Childhood psychosocial risk factors reflecting maladaptive family functioning have, in particular, been strongly associated to the first onset and persistence of mood and anxiety disorders. (Green et al., 2010; McLaughlin et al., 2010) EFA can be limited as it can omit potentially important exposures because they are uncorrelated with other childhood social risk factors. (Evans et al., 2013) A third approach is latent class analysis (LCA). LCA, which is a cluster-analysis (or person-centered method), is based on the child’s exposure to social risk factors grouping children into mutually exclusive homogenous clusters (or classes). From the resultant classes, it becomes apparent which childhood social risk factors co-occur and how they cluster. Recent research has utilized LCA to reveal classes of children exposed to particular patterns of childhood social risk factors. (Dunn et al., 2011; Lee et al., 2015; McLafferty et al., 2015) Different childhood social adversity latent classes have been associated with a range of specific psychiatric disorders including depression and anxiety. (Dunn et al., 2011)

Three approaches (i.e. conceptual, EFA and LCA) were used to summarise exposure to multiple childhood social risk factors and to examine whether any were associated with physical capability and common affective disorders in older adults. We chose to focus on these outcomes because maintaining physical capability and avoiding affective disorders are considered essential components of healthy ageing. (Kuh et al., 2012) Associations of total, domain-specific and latent classes of childhood social risk with physical capability and

common affective symptoms in older age are presented using prospective data from the longest continually running British birth cohort study, the Medical Research Council National Survey of Health and Development (NSHD).

## **Methods**

### **Study Sample**

NSHD is based on a social class stratified sample of 5,362 singleton births that occurred within marriage in a week in March 1946 in England, Scotland and Wales. The outcomes used in this study were obtained between 2006 and 2011 (60-64 years), at the 24<sup>th</sup> follow-up of the NSHD. All 2856 eligible study members (known to be alive and with a known address in England, Scotland or Wales) were invited for an assessment at 1 of 6 clinical research facilities or by a research nurse at home. Those who had died ( $n = 778$ ), were living abroad ( $n = 570$ ), had previously withdrawn from the study ( $n = 594$ ), or had been lost to follow-up ( $n = 564$ ) were not invited. Of those invited, 2229 (78%) were assessed. (Stafford et al., 2013) Ethical approval for the study was obtained from the Greater Manchester Local Research Ethics Committee and the Scotland A Research Ethics Committee. All study members provided written informed consent.

## **Measures**

### **Physical capability at age 60-64 years**

Physical capability, the capacity to undertake the physical tasks of everyday living, was assessed using four performance-based tests (Cooper, Kuh, & Hardy, 2010): grip strength, chair rise time, standing balance time and timed get-up-and-go (TUG). Trained nurses conducted these tests using standardised protocols as described elsewhere. (Kuh, Bassey, Butterworth, Hardy, & Wadsworth, 2005) A composite score of physical capability was

created using the method devised by Guralnik et al. (Guralnik, Butterworth, Wadsworth, & Kuh, 2006) This involved rescaling each of the test scores to a 0 (low performance) to 1 (high performance) scale; assigning those participants unable to perform each test for health reasons a value of 0 and; summing the four rescaled scores to create a normally distributed aggregate physical capability score with a theoretical range of 0 to 4. (Cooper, Strand, Hardy, Patel, & Kuh, 2014)

### **Common affective symptoms**

Frequency and severity of common affective symptoms were assessed with the 28-item General Health Questionnaire (GHQ). Responses were coded using the Likert scale (0-1-2-3). A total symptom score based on all 28 items was calculated (possible range 0-84).

### **Childhood social risk factors**

A description of the seventeen childhood social risk factors used in analyses is given in table 1. Thirteen of these were prospectively measured at age 4 years or at 7 or 11 years if missing (1950-1957) and three were recalled when participants were age 43 (1989).

### **Total childhood cumulative social risk**

Each childhood social risk factor was categorized as indicated in table 1 as unexposed (assigned a value of 0) or exposed (assigned a value of 1). The individual binary childhood social risk factors were summed to create a total cumulative social risk metric (possible range 0 to 17). Higher scores (i.e. those  $\geq 4$ ) were combined in an upper category due to small numbers.

### **Defining childhood social risk**



### **Conceptual/researcher-driven approach**

Childhood social risk factors were divided into two groups either reflecting socioeconomic or psychosocial disadvantage. The socioeconomic group includes the social and economic factors that influence which positions individuals or groups will hold within the structure of a society. (B. Galobardes, Shaw, Lawlor, Lynch, & Davey Smith, 2006a, 2006b; N. Krieger, Williams, & Moss, 1997; Lynch et al., 2001) This also includes housing characteristics and amenities as markers of material circumstances (B. Galobardes, Shaw, Lawlor, Smith, & Lynch, 2006) and children's living conditions related to parent's financial resources. (Evans & Kantrowitz, 2002; Hakovirta & Kallio, 2016; Weinger, 2000) There is no agreed definition of psychosocial risk, (Martikainen, Bartley, & Lahelma, 2002) however a psychosocial risk factor can be defined as a characteristic that relates psychological phenomena to the social environment and/or to pathophysiological changes. (Neylon et al., 2013) This broad definition reflects the wide variety of psychosocial variables, which have been studied in the etiology of adult health. (Felitti et al., 1998) The nine binary childhood factors reflecting socioeconomic disadvantage (low maternal education, low father social class, private landlord owned home, poor household amenities, overcrowding, poorly repaired house, unclean child, poorly cleaned house, and poor state of child's clothes and shoes) and eight childhood factors reflecting psychosocial disadvantage (maltreatment, low parental concern for their child's education, parental psychiatric history, parental divorce, mother's affectionless control, father's affectionless control, parent death and maternal separation) were used to create two domain-specific cumulative social risk indices.

### **Factor analysis approach**

Exploratory tetrachoric factor analysis (EFA) using weighted least square mean and variance (WLSMV) estimation was used to identify sub-domains of childhood social risk from the

data.<sup>23</sup> The final factor solution and interpretation was based on model fit and model interpretability. Factor loading cut-offs were set at 0.30 for derivation of the factors scores. (Hair, Tatham, Anderson, & Black, 1998) The model was considered to fit the data well if any of the following goodness-of-fit indices were satisfied: root mean square error of approximation (RMSEA)  $\leq 0.06$ , or root mean square of the residuals RMSR  $\leq 0.08$ . (McLachlan & Peel, 2000; Muthen & Muthen, 2001)

### **Latent Class Analysis Approach**

LCA is a multivariate regression model that describes the relations between a set of latent class indicators (in this case the childhood social risk factors), and an unobserved categorical latent variable, each level of which is referred to as a “latent class.” This statistical technique was employed to determine the number and nature of subgroups of childhood social risk exposure based on the absence or presence of exposure to each of the 17 factors. The fit of models estimating 1-class through 5-class solutions were compared. Because there is no single accepted statistical index for comparing latent class solutions several criteria were considered including Bayesian information criteria (BIC) values, exclusion of solutions with rare classes ( $< 5\%$ ), and entropy values. Class solutions with lower BIC values typically provide the best fit to the data. However, because the BIC tends to underestimate the number of classes, we assessed both the class solution with the lowest BIC value and the class + 1 solution. (McLachlan & Peel, 2000) Entropy with values approaching 1 indicate clear delineation of classes. (Celeux & Soromenho, 1996)

### **Statistical analysis of associations between childhood risk and outcomes at age 60-64 years**

Linear regression was used to estimate the associations of the total childhood cumulative social risk metric with physical capability and common affective symptoms at 60-64 years. We found no overall evidence of interaction between gender and any of the cumulative childhood risk measures and so results are presented for men and women together with adjustment for gender. Where separate domains of social risk were considered, models were additionally adjusted for other domains. In the regression analyses, data missingness (table 1) were handled using multiple imputation by chained equations (MICE) with 10 complete datasets created, (Kenward & Carpenter, 2007; Sterne et al., 2009) and in EFA and LCA, by using full information maximum likelihood estimation under the assumption that the data were missing at random. EFA and LCA were conducted using Mplus version 7.31 and regression analyses were conducted using Stata version 13.0 (Stata, College Station, TX, USA). All analyses were conducted in 2015-2016.

We presented descriptive statistics, EFA and LCA based on the 5,148 study members after excluding participants who had missing information on  $\geq 12$  out of the 16 childhood social risk factors. For the regression analyses, we excluded those with missing information at age 60-64 on assessments of physical capability (yielding  $n=1,991$  with data) and common affective symptoms ( $n=2,190$ ) respectively. The prevalence of childhood adversities was greater in those study members with missing outcome data than in the analytical sample, with the exception of parental psychiatric history, parental divorce, parental bonding and parental death (Table 1).

## **Results**

Prevalence and co-occurrence of childhood social risk factors

Thirty one percent of participants reported exposure to at least four childhood social risk factors (supplementary table 1). The most common childhood social risk factors were low maternal education (64%), living in a private landlord owned house (54%), low father's social class (28%), and recalled indicators of maternal and paternal affectionless control (30%). A total of 27% participants were exposed to three or more childhood socioeconomic risk factors and 10% were exposed to three or more childhood psychosocial risk factors.

### **Data-driven domains of childhood risk**

A total of 105 (87.5%) of the 120 tetrachoric correlations between pairs of childhood social risk factors were positive indicating that the childhood social risk factors co-occur (data available on request).

Exploratory factor analysis found 3 meaningful factors (supplementary table 2 and 3). The first factor represented "Socio-economic and material disadvantage" (i.e. low maternal education, low father's social class, private landlord owned house, poor amenities, and poorly repaired house). The second factor represented "Overcrowding, physical neglect and low parental concern for child's education" and included low maternal education, overcrowding, unclean child, poorly cleaned house, poor state of child's clothes, and low parental concern for child's education). The third factor represented "Maladaptive family functioning" (maltreatment, mother's affectionless control, father's affectionless control).

Childhood social risk latent classes

After comparing several model fit criteria and the interpretability, a best model that fit the data both statistically and substantively was not found (supplementary table 4). While the BIC fit statistics indicated a better, more parsimonious model when more classes were added, entropy scores were low ( $< 0.8$ ) representing poor classification accuracy. We therefore do not present outcomes by latent classes.

#### Associations with physical capability at age 60-64 years

Mean sex-adjusted physical capability scores were lower with more childhood social risk factors ( $P$  for trend  $< 0.001$ ) (table 2). Mean physical capability scores were also low with more childhood socioeconomic risk factors, and even after adjustment for exposure to childhood psychosocial risk factors ( $P$  for trend  $< 0.001$ ). There was evidence for a trend for lower physical capability scores with more childhood psychosocial risk factors ( $P$  for trend =  $0.008$ ) although this association was weaker than the association with childhood socioeconomic risk factors.

Based on the data-driven factors, mean physical capability scores were lower with more risk factors from the “Socio-economic and material disadvantage” domain ( $P$  for trend  $< 0.001$ ) (table 3) even after adjustment for “Overcrowding, physical neglect and low parental concern for child’s education” and “Maladaptive family functioning”. Additionally, mean physical capability scores were lower with more risk factors from the “Overcrowding, physical neglect and low parental concern for child’s education” domain ( $P$  for trend  $< 0.02$ ) even after adjustment for “Socio-economic and material disadvantage” and “Maladaptive family functioning”. The other data-driven childhood cumulative social risk domain “Maladaptive family functioning” was not independently associated with physical capability. In all

regression models (that is, for researcher-driven and data-driven methods for summarizing childhood adversity), the variance in physical capability explained was low (adjusted R-square <0.03).

#### Associations with common affective symptoms at age 60-64 years

The mean sex-adjusted common affective symptom score was higher with more childhood social risk factors ( $P$  for trend <0.001) (table 2). Common affective symptoms were higher with more childhood psychosocial risk factors ( $P$  for trend <0.001) even after adjustment for exposure to childhood socioeconomic risk factors. There was no association between cumulative exposure to childhood socioeconomic risk factors and common affective symptoms.

According to data-driven childhood cumulative social risk domains, mean sex-adjusted common affective symptoms was higher with more risk factors from the “Maladaptive family functioning” domain ( $P$  for trend <0.001) (table 3). The results did not change after mutually adjusting for each of childhood cumulative social risk domains. There was no evidence that the other data-driven childhood cumulative social risk domains were associated with common affective symptoms (table 3). Adjusted R-square values were low (<0.04 in all regression models relating childhood adversity to common affective symptoms).

## **Discussion**

We have described three approaches to examining multiple childhood social risk exposures and relating these to physical capability and common affective symptoms in later life. Both the cumulative risk approach and factor analysis provided evidence that children who are exposed to multiple social risk factors had lower levels of physical capability and more symptoms of common affective symptoms in later life. It was not possible to relate childhood social risk to our outcomes using LCA as no model found was optimal.

Very little information exists on the association between exposure to multiple childhood social risk factors and physical capability in later life. The 2009-2010 Behavioral Risk Factor Surveillance System (BRFSS) (Schussler-Fiorenza Rose, Xie, & Stineman, 2014) reported a strong graded association between childhood psychosocial risk factors and self-reported disability (self-reported activity limitation and/or assistive device use) in adulthood, but did not control for childhood socioeconomic risk factors. In contrast, we were able to jointly examine cumulative exposure to childhood socioeconomic and psychosocial risk factors, as well as incorporate a performance-based measure of physical capability, which has been shown to be associated with all-cause mortality. (Cooper et al., 2014) We found some evidence of an association between psychosocial risk factors and poorer physical capability, independently of socioeconomic risk factors, though effect sizes for the latter were considerably larger. This was confirmed in the exploratory factor analysis approach, which did not group the risk factors in an identical way to the researcher-driven approach but nevertheless identified that socioeconomic and psychosocial risk factors in the “Socio-economic and material disadvantage” and the “Overcrowding/physical neglect/low parental concern for child’s education” domains contributed to explaining differences in physical

capability in later life. This builds on evidence from this cohort and others (Birnie et al., 2011; Murray et al., 2011; Strand, Cooper, Hardy, Kuh, & Guralnik, 2011) showing that lower childhood social class is strongly associated with poorer performance-based physical capability and self-reported functional limitations since we were able to distinguish different components of childhood disadvantage. Future work might consider the distinct performance tests which make up the composite physical capability score used here.

Several studies from the United States have demonstrated that exposure to multiple childhood social risk factors are associated with an increased risk of mood disorder in a graded manner: (Chapman et al., 2004; Kessler, Davis, & Kendler, 1997; McLaughlin et al., 2010; Raposo, Mackenzie, Henriksen, & Afifi, 2014) the higher the number of childhood social risk factors, the higher the probability of mood disorder. These studies used retrospective measures of childhood psychosocial risk factors and were not able to examine the co-occurrence of both childhood socioeconomic and psychosocial risk factors. Our study suggests that the association between affective symptoms and psychosocial adversity are not confounded by socioeconomic disadvantage and that it is primarily “Maladaptive family functioning” which is linked to more common affective symptoms. This aligns with evidence from the National Comorbidity Survey Replication showing that individuals in the “maladaptive family functioning” group were most vulnerable to develop and persist in depression. (Green et al., 2010; McLaughlin et al., 2010)

Childhood social risk factors associated with maladaptive family functioning (e.g. child maltreatment, mother affectionless control, and father affectionless control) were recalled when participants were age 43 years. The validity of retrospective reports about maltreatment, childrearing, and family conflicts has been questioned due to the quality of a



participant's memory, how participants evaluated the experience when looking back on it, and whether they choose to disclose these experiences. (Susser & Widom, 2012) Participants could have been more likely to report these adverse experiences due to a search for potential causes of their common affective symptoms experience by age 43 years, with the net effect of this recall bias to inflate the regression coefficients. However, such an upward bias would be less likely to influence the interpretation of our results as common affective symptoms were measured between 60-64 years.

Examining cumulative risk on the basis of exposure to the sum of individual childhood social risk factors acknowledges that childhood social risk factors tend to accumulate and increases the statistical power when some exposures to specific childhood social risk factors are not common. Formulating metrics of multiple childhood social risk factor exposures into a composite metric may also reduce measurement error. Further challenges exist to construct different domains of risk that children confront in their daily lives. (Evans et al., 2013) For e.g. the term child maltreatment has a broad definition including physical abuse; sexual abuse; emotional abuse; exploitation; and neglect and negligent treatment. An unclean child, poorly cleaned house or poor state of child's clothes and shoes may therefore reflect neglectful parenting but it may also reflect living in poverty or unsuitable housing. Given that these risk factors may overlap attempting to separate these into distinct conceptual groups is challenging. The total cumulative risk approach assumes that different types of social risk exposures have an equivalent impact on the risk of physical or mental capability. This misses the opportunity to examine what happens when children are exposed to social risk factors in different domains of risk within the family environment. Factor analysis partly addresses this issue by allowing the identification of a smaller number of

empirically derived, grouped social risk factors thus helping to understand the separate or unique contributions of different kinds of social risk factors on different ageing outcomes. While LCA can be used to summarize key combinations of social risk that children are exposed to, and examine which of those combinations or risk profiles are most strongly predictive of later functioning, the resulting classes are analysis-specific and may not be generalisable across studies. Second, cases with complete data were small in number. We retained study members with missing childhood exposures under the (untestable) assumption that these items were missing at random. The imputation model was based on a large number of childhood exposures but we acknowledge that missingness was larger for some of the psychosocial measures. Despite a clinical assessment response rate of almost 80% at age 60-64, a substantial proportion of study members were not included in the regression analysis of childhood adversity with age 60-64 outcomes. These had a higher prevalence of childhood adversity and, from previous work,<sup>24</sup> are known to have poorer physical performance and more functional limitations though did not differ in mental health profiles through adulthood or in mood disorder at the previous sweep. Put together, this indicates that those missing from the regression analyses were more deprived (in socioeconomic and psychosocial aspects) in childhood and had poor physical performance but we do not have reason to think that the association between these would be materially different in the analytical and excluded samples.

## **Conclusions**

Domains of social risk based on researcher-driven and data-driven criteria can be identified and provide further insight into the elements of childhood environments that are linked to

ageing outcomes. Greater total childhood cumulative social risk is associated with poorer physical capability and common affective symptoms in older age. Both socioeconomic and psychosocial exposures are relevant for physical capability, though with larger effect sizes for socioeconomic exposures. Greater exposure to psychosocial risk factors in childhood was associated with common affective symptoms in older age and this was not explained by childhood socioeconomic risk factors. The cumulative social risk metric approach is simple and generalizable and, in terms of associations with indicators of healthy ageing, aligned with results from the use of factor analysis, though the latter is study-specific and not so easily generalizable. Both approaches identify contexts of social risk that children confront in their daily lives and offer viable methods for characterizing the complex combinations of childhood social risk factors and their associations to later life physical and mental capability.



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